USERS' PREFERENCE IN SMART HIGHWAYS

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ABSTRACT
Traffic congestion in the metropolitan areas in Korea has been getting worse because auto ownership ha s been shapely increasing since 1980 and the expansion of highway network lagged far behind a dema nd. Thus, express highways that pass through a metropolitan areas loss a function as trunk roads. Also, car users want to receive better service from express highways. To cope with problems that are now be ing faced, we start considering building the next generation of highways, SMART highway. The SMAR T Highway can decrease the congestions and increase the safety of users by accommodating advanced I TS (Intelligent Transportation Systems). This research analyzes road users' preference to SMART Highw ays, based on interview survey data, by applying a duration model. The estimation results show that users' WTP (Willingness to Pay) is 877 won (log-logistic distribution) or 944 won (Weibull distribution) per person for the service of SMART Highway that improve safety. The value of the service to improve on-time quality in SMART Highway is estimated to 924 won (log-logistic distribution) per one person.

1. INTRODUCTION

Express highways in Korea have had 26 lines and 3,368km in 2007 since Kyungbu express highway was built in 1970, have being played a key role in developing a national economy by activating local economy and supporting industries. A fast increase in vehicles, however, annually made congestion charge up to 24.601 trillion won (congestion cost in express highways was 2.437 trillion won) and logistics cost up to 131.549 trillion won in 2005 and 2006 for 1 year. Cost in congestion and logistics take 16.3% and 2.9% of GDP of Korea, which means huge amount of money has being wasted in roadways.

Also, number of traffic accident death per a billion-travel km was 9.5 persons in major developed countries (Japan, U.K., USA, and France) whereas Korea was 13.7, in 2004. Thus these facts starts to call for another road system with the more safety equipped.

Table 1. Comparison of Death in Traffic Accidents in OECD (2004 year)

	Korea	Japan	U.K.	U.S.A	France
Total number of death	6,563	8,492	3,368	42,636	5,530
- per 100 thousand person	13.7	6.7	5.6	14.5	9.2
- per 10 thousand vehicle	3.6	1.0	1.0	1.8	1.5
- per 1 billion travel km	23.1	11.2	7.6	9.4	9.9

Source: 6th master plan of traffic safety (KOTI, 2006)

Moreover an aging society is getting fast on its way so the demand for the safer road is rising. With the speed of heading to an aging society by UN statistics, the senior citizen was over 7% of total Korean population which an aging society was already starting, 15.6% in 2020 on its way and in 2025 it would be estimated to reach to a post-aged society with 19.9% (the National Statistical Office, 2006). Older drivers would be expected to rise rapidly and the percentage of aged over 60 people among total drivers would be expected 5.1% in 2004 to 30% increasing within 20 years. Currently aged over 65 driving license holders in Korea are 9.5 million in 2008, occupied 3.8% of the total number (252.7 million). Generally older drivers do not have good sense of exercise and are poor at controlling a car so they tend to cause many accidents. Road accidents by aged over 60 increased 3.9 times from 2,895 cases in 1999 to 11,157 cases in 2004. The rate of older drivers' death in car accidents was 5.5% which was higher than other age group by double (KIDI, 2006). So the demand, which calls for safer and more convenient traffic facilities, environment, would be enormously increasing.

By the changes in social circumstance and transportation environment, Korea has researched and developed SMART Highways that is next generation express highways and the combination of several technologies in IT, roadways, and automobile. The aim of this study is to reveal the effects of SMART Highways by analyzing the preference of users for SMART Highways.

2. METHODOLOGY

1) Users' preference by transportation modes

We apply 'User Value Equation' that was used in Kim et al. (2008), to compare the users' preference between transportation modes, airplane, high speed railways (KTX: Korea Train Express), and cars, in intercity passenger travel city. Users' preference by its transportation modes reflects user's expectations and perceptions about each transportation modes. Therefore users' preference can imply the competitiveness among them.

'User Value Equation' is shown in Table 1. For an automobile (driving on express highways), items of expense are automobile purchasing expense and use expense (oil cost and toll expense), and items of service are the mobility, the convenience (accessibility and waiting time), and the driving fatigue. For an airplane and KTX, an item of expense takes into account a fare of an airplane or KTX, and items of service are accessibility and waiting time.

Table 2. User Value Equation

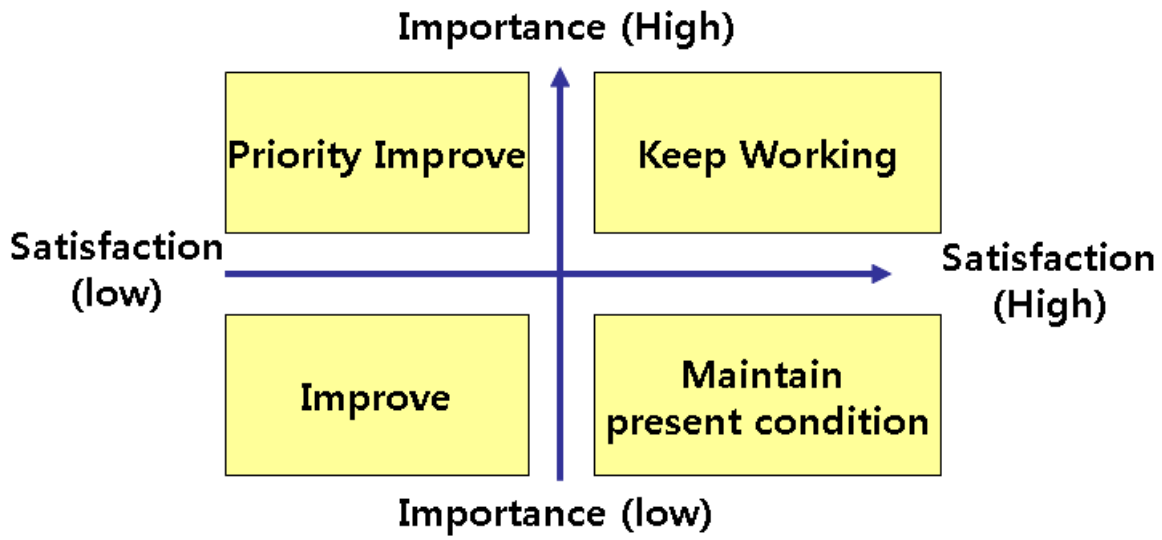
	Transportation Mode	
	Automobile	**Airplane and KTX**
Conception	$\frac{(\text{Results of Travel} + \text{Quality of Process})}{(\text{Price of Purchase} + \text{Cost of Oil})}$	$\frac{(\text{Results of Travel} + \text{Quality of Process})}{(\text{Fare})}$
Equation	$\frac{(AW_i^m \cdot AM_i) + \sum_{k=1}^{n} \frac{(AW_i^k \cdot AC_i^k)}{n}}{(AW_i^c \cdot AP_i) + (AW_i^g \cdot AG_i)}$ AW_i^m: Waiting factor for mobility of a car AM_i: Degree of satisfaction in mobility of a car AW_i^k: Waiging factor for convenience k AC_i^k: Degree of satisfaction in convenicence k AW_i^c: Waiting factor for price of purchase AP_i: Degree of satisfaction in price of purchase AW_i^g : Waiting factor in cost of oil AG_i : Degree of satisfaction in cost of oil i : User i	$\frac{(TW_i^m \cdot TM_i) + (\sum_{k=1}^{n} (TW_i^k \cdot TC_i^k)/n)^{-1}}{(TW_i^g \cdot TP_i)}$ TW_i^m: Waiting factor for mobility of an airplane and KTX TM_i: Degree of satisfaction in mobility of an airplane and KTX TC_i^k: Waiging factor for convenience k TW_i^k: Degree of satisfaction in convenicence k TW_i^g: Waiting factor for fare TP_i: Degree of satisfaction in fare i : user i

Source : Kim et al. (2008)

2) Comparison between the importance and the satisfaction

We conducted Importance-Performance Analysis (IPA) for evaluating service of transportation modes (on-time, convenience, etc.). When using IPA analysis we can find out how users recognize the importance and the satisfaction about transportation mode, so in policy we can notice which service lists are urgent things to be improved.

IPA has Y-axis which shows the importance and X-axis shows the satisfaction. When service that locates in the first quadrant, a user thinks that the service is important, and is satisfied, so a service provider needs to keep it working on. When service locates in the second quadrant, the satisfaction is low while users think that service is important. Therefore a service provider needs to make a priority improve of the quality of the service. If a service is locating in the third quadrant, both importance and satisfaction are low. Then the service needs to be improved. When a service locates in the fourth quadrant the importance is low about service but they give high score on the satisfaction so it needs to keep them going.



Source: Kim et al. (2008)

Figure 1. IPA Analysis

3) Evaluation of Value of SMART Highway

SMART Highway is the next generation express highways that has the new system, any express highways has never applied yet, is researched and developed to enhance the safety and to reduce congestion. Thus it needs to analyze how this system is worth using for drivers. The value that users feel can be analyzed by users' willingness to pay (WTP) that firstly the virtual cases are supposing, and asking users, then it comes out how worth paying to receive the service.

In general speaking, there are two ways to analyze WTP. The first one is CVM (Contingent Valuation Method) which is direct survey method to ask WTP, and the second one is CE (Choice Experiments) which ask the preference on a case by case. If respondents recognize evaluation items by considering whole things, then CVM would be better method than CE (Jang Sueun, 2008).

Survival analysis (or duration model) has been used to analyze a contingency in duration data in the field of industrial engineering and biomedical, but recently it has been used to analyze accidents in transportation (Mannering, 1993; Nam and Mannering, 2000). In survival analysis, interest is the duration of the time when it starts and finishes. Duration model can be used to analyze WTP because WTP can be considered as duration data.

Exponential distribution, Weibull distribution, Log-logistic distribution, etc are generally used as a duration model. In the case of exponential distribution, hazard function has a constant value regardless of time. However, Weibull distribution shows monotonic increase or monotonic decrease. Log-logistic distribution is able to express increasing and decreasing phenomenon, by having inconstant rate of increasing or decreasing according to time. In order to evaluate model which

distribution is statistically superior, likelihood ratio test that the Nam and Mannering (200) applied is used.

In this study, to raise the reliability of estimating value of the model we estimate parameters with significant level 10%, and select the final model based on statistical tests.

3. DATA

The user's preference analysis of SMART Highways is consisted of two parts, the survey of the preference of cars and value of SMART highway to public and the survey of the future transportation environment to experts.

The survey by the public was carried out in resting place on express highways railway stations, airports by face to face survey method from 2nd of April to 4th. And the survey by the experts about the prospects of future transportation environment was carried out from 16th of March to 28th.

Table 3. The Outline of Survey

	Public	Expert
Date	·Preliminary survey: Mar. 18(Wed)~Mar.19(Thu) ·Primary survey: Apr. 2(Thu)~Apr. 4(Sat)	·Preliminary survey: Mar. 16(Mon)~ Mar. 28(Sat) ·Primary survey: Apr. 23(Thu)~May. 6(Sat)
Location and Target	·Resting area: four places ·Railway station: two places ·Airport: one place	·Research Institutes and IT company ·Korean Society of Transportation Korean Society of Road Engineering Korea Express Corporation Korea Planners Association Ministry of Land, Transport and Maritime Affairs, Non-Governmental Organization
Method	·Face to face survey	·Face to Face survey and On-line
Number of data	·Preliminary survey (154) ·Primary survey (744)	·Preliminary survey (38) ·Primary survey (200)

4. RESULT

1) Users' preference by transportation modes

We analyzed users' preference in intercity passenger trips by transportation modes. The preference about transportation modes did not show certain patterns by its axis (Seoul-Busan and the Honam) and travel distance, but by objectives of travel (i.e., business trip and non business trip) it had a certain patterns. KTX and airplane had higher preference in business trip than in non-business trips. Concerning a car, however, there was no difference in preference between business trips and non-business trips. The preference for a car, KTX, and an airplane were 1.093, 0.674, and 0.451, respectively. That is, the preference for a car was 1.6 times than KTX and 2.4 times than an airplane.

In intercity trips, it is expected to the demand of car keep increasing, so to meet the demand it is required to persistently improve highways.

Table 4. The Results of preference by modes

			Car (Highways)	KTX	Airplane
Objective of Trips	Business trip		1.09	0.74	0.58
	Non-Business trip		1.09	0.63	0.40
Trip Distance	The Axis of Seoul-Busan	Seoul-Daejon	1.08	0.65	-
		Seoul-Daegu	1.14	0.75	-
		Seoul - Busan	1.10	0.62	0.37
		Average	1.10	0.66	0.37
	The Axis of Honam	Seoul-Iksan	1.08	0.67	-
		Seoul-Kwangjoo	1.13	0.63	0.51
		Seoul-Mokpo	1.05	0.78	0.38
		Average	1.09	0.69	0.45
Total			1.09	0.67	0.45

2) Comparison between the importance and the satisfaction

Through IPA analysis, it has been revealed that we need to improve punctuality of a car (i.e., no congestion) Thus SMART Highway should guarantee that a car has to drive on above a certain speed to keep on-time quality.

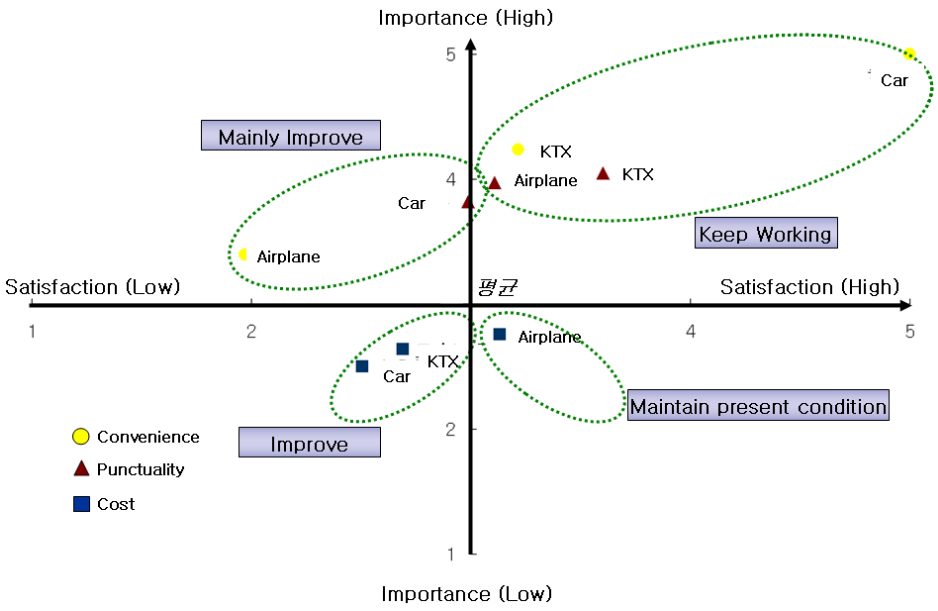


Figure 1. The Results of IPA Analysis

3) Evaluation of Value of SMART Highway

The results of this study show that users' WTP is 877 won (log-logistic distribution) or 944 won (Weibull distribution) per person for the service of SMART Highway that improves safety (for examples, information of forward traffic the condition, information of obstacles on roads, information of a frozen condition on roads, and alarm service when a car deviates from its lane. That is, the value of the service of SMART Highway to improve safety is 877 won or 944 won.

When applying Weibull distribution model, WTP of the aged over 40 is reduced. If annual household income is more than 30 million won, then WTP increases.

The model build by applying log-logistic distribution reveals that WTP of men, aged over 60, and SUV drivers decrease, but WTP increases if annual household income is more than 30 million.

In sum, WTP of the safety system of SMART Highway increases as annual household income increases, and decreases if a driver is man.

Table 5. Willing to Pay for the Service of Safety System

	Weibull	Log-logistic
Constant	6.994	6.915
Male		-0.197
Above 40 year old	-0.280	
Above 60 year old		-0.283
Annual household income, >= 30 million won	0.402	0.178
SUV		-0.215
p	2.128	3.692
WTP	943.9 원	877.1 원
Observations	141	141
Log-likelihood	-108.226	-95.183

* The level of significance: all greater than 90%

In the survey, the major reasons why express highways were unsafe are 'driving habit of other drivers (38%)' and 'driving together with trucks (32%).' 'Driving habit of other drivers' is related with 'jumping into lanes without enough space', 'intruding the lanes.' Therefore, the safety improving system, which is SMART Highway's 'lanes intruding prevention', is expected to improve the safety users can feel. But it needs further analysis on how trucks are to run on SMART Highway.

WTP of non-congestion service in express highways has been worth 924 won. In other words, the value of the service to improve on-time quality in SMART Highway has been worth 924 won (Log-logistic) per one person

WTP of non-congestion service is increased when annual income of users is more than 60 million won, whereas WTP of car drivers and SUV drivers is decreased..

Table 6. Willing to Pay for the Service of Safety System 비정체 서비스에 대한 지불의사액

	Log-logistic 분포
Constant	7.013
Annual household income >= 60 million won	0.230
Passenger car and SUV	-0.238
P	3.501
WTP	924.3 원
Number of observation	144
Log-likelihood	-106.86

* The level of significance: all greater than 90%

According to the survey, the major factor to feel uncomfortable when driving on express highways was congestion (66.3% of its respondents). So SMART Highway should provide the service to keep a certain level of speed to meet the needs of drivers who want to get the destination on time.

4) Future traffic environment expectation by experts

We carried out the survey of the experts asking an image of the future of express highways regarding automobile technology development, IT technology development, and environment and culture changes.

As we forecast express highways related to future automobile technology development, it is predicted to provide customized information to the drivers by mutual communication between a road and a vehicle (66%), more alternative energy stations on the express highways due to an increase of vehicles using alternative energy (16%). new driving method introduced to give the drivers the best environment by limiting the vehicles in its possible lanes to use (13%).

As we forecast express highways related to future IT technology development, it is predicted to get provided a variety of information such as emergency rescue and transportation when driving on express highways (56%). The number of tool gates will be reduced and its function is changed because of an increase of ETC; electronic toll collection (13%). It is predicted that the function of 'the rest area' in express highways is changed because IT technology development makes automated system possible and alternative energy is widely used (8%). Express highways would be constructed in an eco-friendly way due to the reduction of harmful substances and development of IT technology affecting to generate eco-friendly cars (5%).

As we forecast highways related to future social culture and environment change, automobile control system becomes better because of broad use of decision-making system based on computer (21%). The network system that can be able to communicate information of vehicles, roads, and living space, would be built (21%). Besides it is predicted that the safety management is strengthened for senior citizens who are not good at driving (13%).

Features of future express highways the experts expect are: providing customized information to drivers seamlessly, improving vehicle control system, the increase of eco-vehicle using renewable energy. Thus, SMART Highway should be developed in a way of providing the useful information quickly and conveniently on real-time.

5. CONCLUSIONS

This study analyzes road users' preference to SMART Highways, based on interview survey data, by applying a duration model. The analysis was based on the survey data from 2nd of April to 4th for general and from 16th of March to 28th for experts.

The estimation results show that users' WTP is 877 won (log-logistic distribution) or 944 won (Weibull distribution) per person for the service of SMART Highway that improve safety. WTP of safety system of SMART highway increases as annual household income increases. And if a driver is man, WTP decreases. The value of the service to improve on-time quality in SMART Highway is estimated to 924 won (log-logistic distribution) per one person.

Further study needs to explore detailed how to operate SMART Highway (for example, will trucks run with a passenger car together?). Also, we need to consider the equity of people (for example, how about the people having no equipped unit for SMART Highway to receive information.

6. ACKNOWLEDGEMENT

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